

REPORT DOCUMENTATION PAGE

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18 May 1998

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-TP-1998-104**
Tim Miller (SPARTA) "Modeling of Interfacial Fracture in Photoelastic Specimens"

Vugraphs

(Statement A)



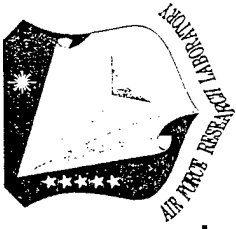
Modeling of Interfacial Fracture in Photoelastic Specimens

T.C. Miller

**Sparta, Incorporated
Air Force Research Laboratory
Edwards Air Force Base, California**

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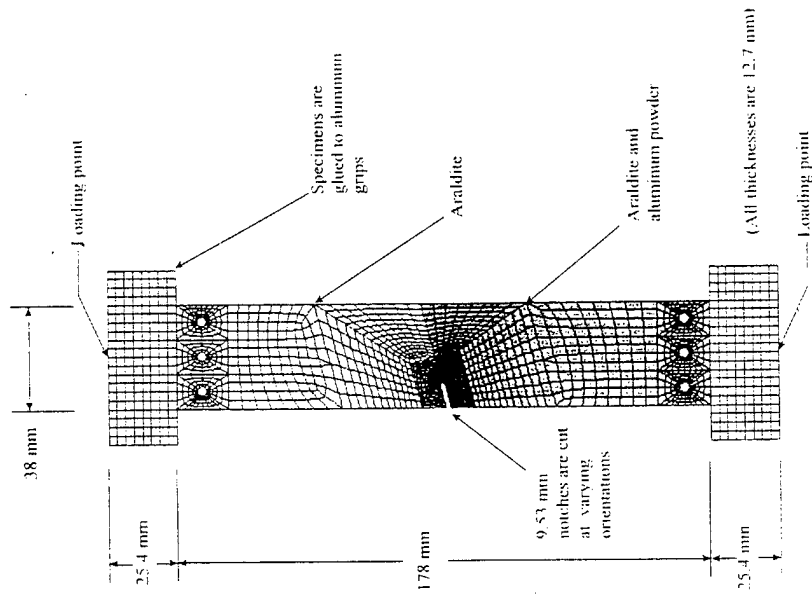
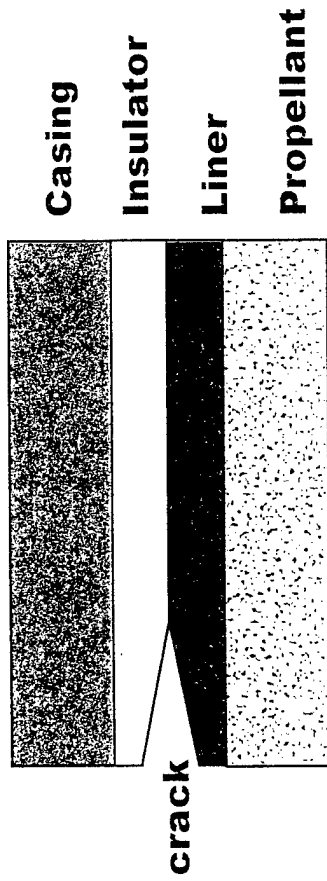
June 1998



Introduction

Applications to Composite Structures

Related Photoelastic Stress Freezing Experiments





Incompressible Bimaterial Paris Under Plane Strain Conditions

General Interfacial Fracture

Plane Strain/Incompressible Materials

$$\epsilon \neq 0 \quad \beta \neq 0$$

$$\sigma_{pq} = \frac{1}{\sqrt{2\pi r}} \{ \text{Re}(K r^{i\epsilon}) \Sigma_{pq}^I(\theta) + \text{Im}(K r^{i\epsilon}) \Sigma_{pq}^{II}(\theta) \}$$

$$(\sigma_{yy} + i\sigma_{xy})_{\theta=0} = \frac{K r^{i\epsilon}}{\sqrt{2\pi r}} = \frac{K_1 + iK_2}{\sqrt{2\pi r}} [\cos(\epsilon Lnr) + i \sin(\epsilon Lnr)]$$

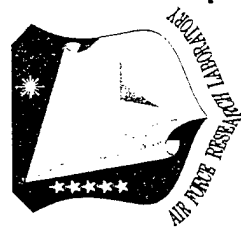
$$J = G = \frac{\Lambda_1 + \Lambda_2}{16 \cosh^2(\pi\epsilon)} |K|^2$$

$$\epsilon = 0 \quad \beta = 0$$

$$\sigma_{pq} = \frac{1}{\sqrt{2\pi r}} \{ \text{Re}(K) \Sigma_{pq}^I(\theta) + \text{Im}(K) \Sigma_{pq}^{II}(\theta) \}$$

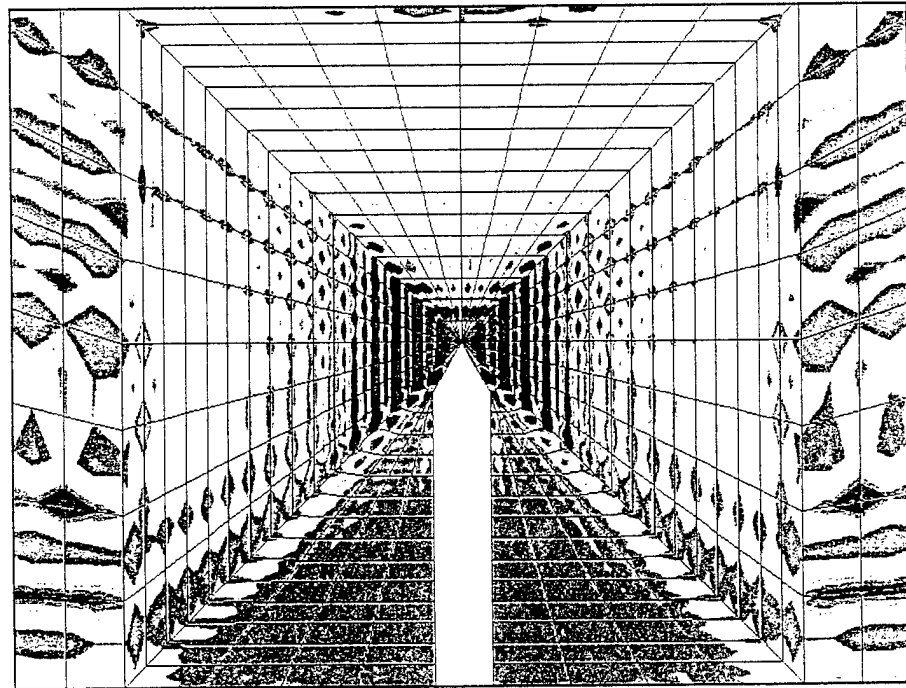
$$(\sigma_{yy} + i\sigma_{xy})_{\theta=0} = \frac{K}{\sqrt{2\pi r}} = \frac{K_1 + iK_2}{\sqrt{2\pi r}}$$

$$J = G = \frac{K^2}{E^*}, \quad \frac{1}{E^*} = \frac{1}{2} \left[\frac{1}{E_1} + \frac{1}{E_2} \right], \quad \bar{E}_1 = \frac{E_1}{1 - \nu_1^2}, \quad \bar{E}_2 = \frac{E_2}{1 - \nu_2^2}$$

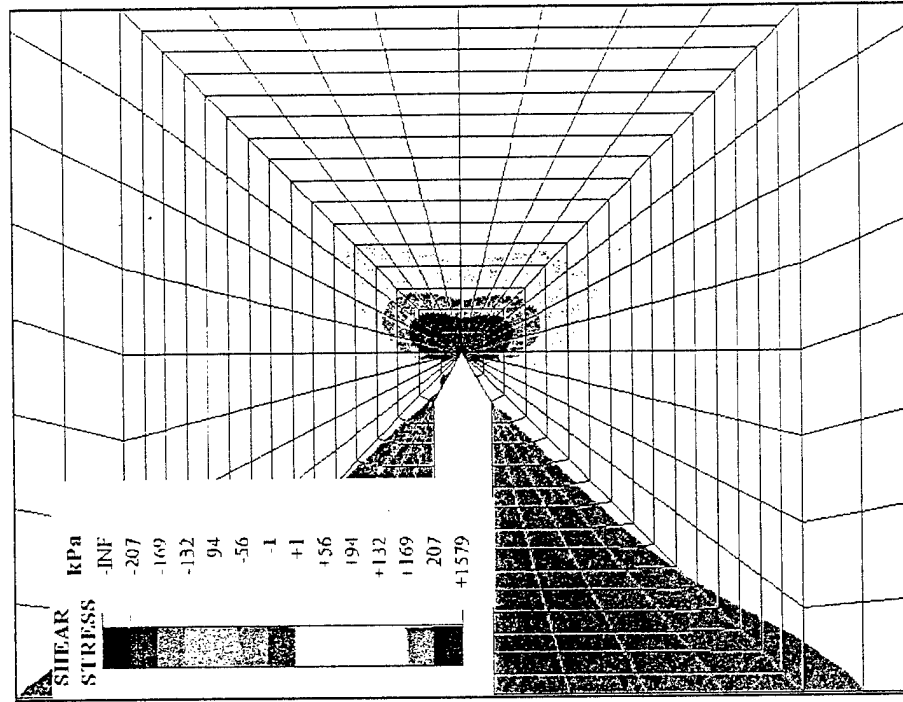


Hybrid Elements and Mixed Formulation Prevent Ill-Conditioning Problems

Conventional Formulation

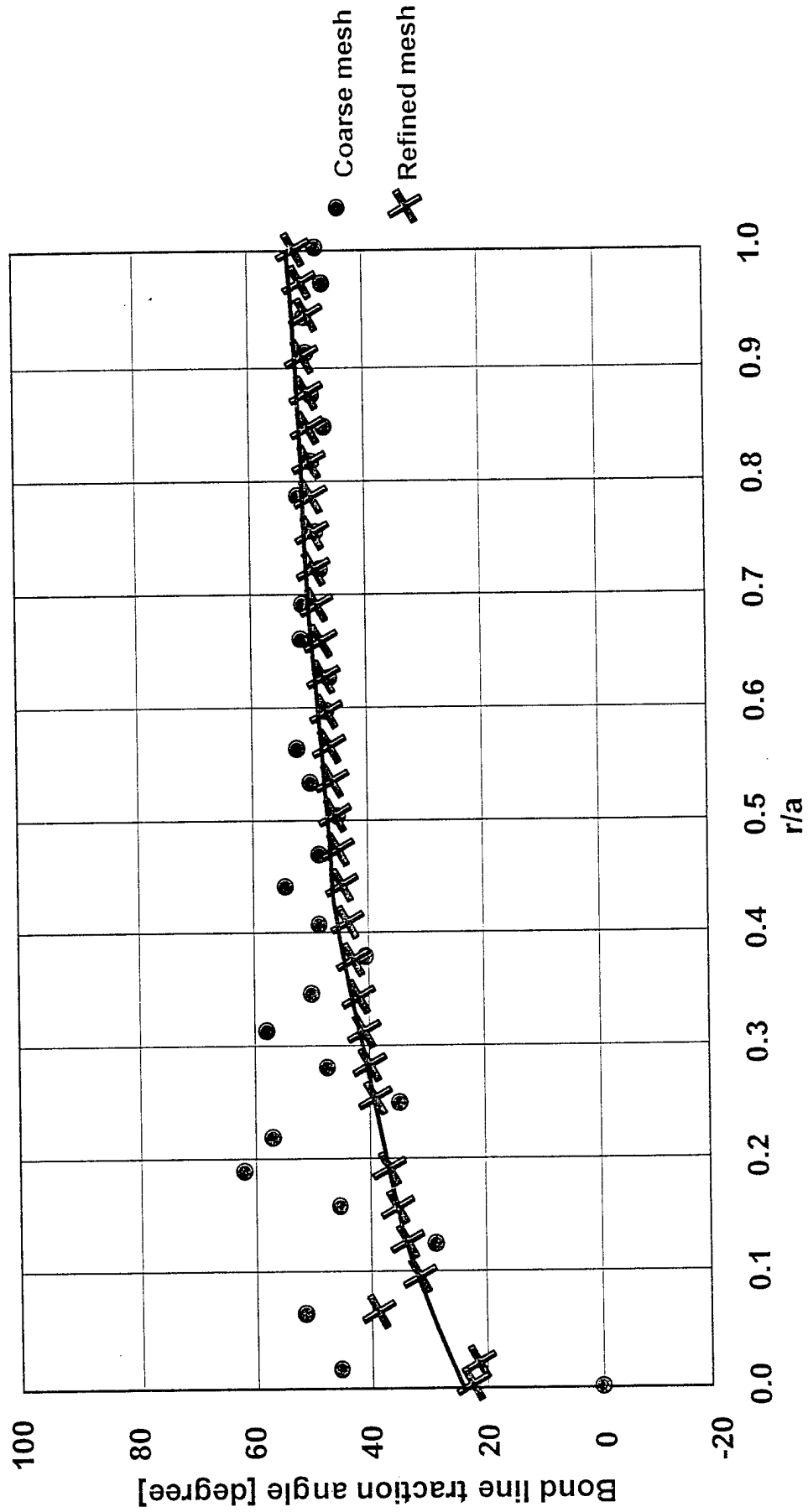


Mixed Formulation

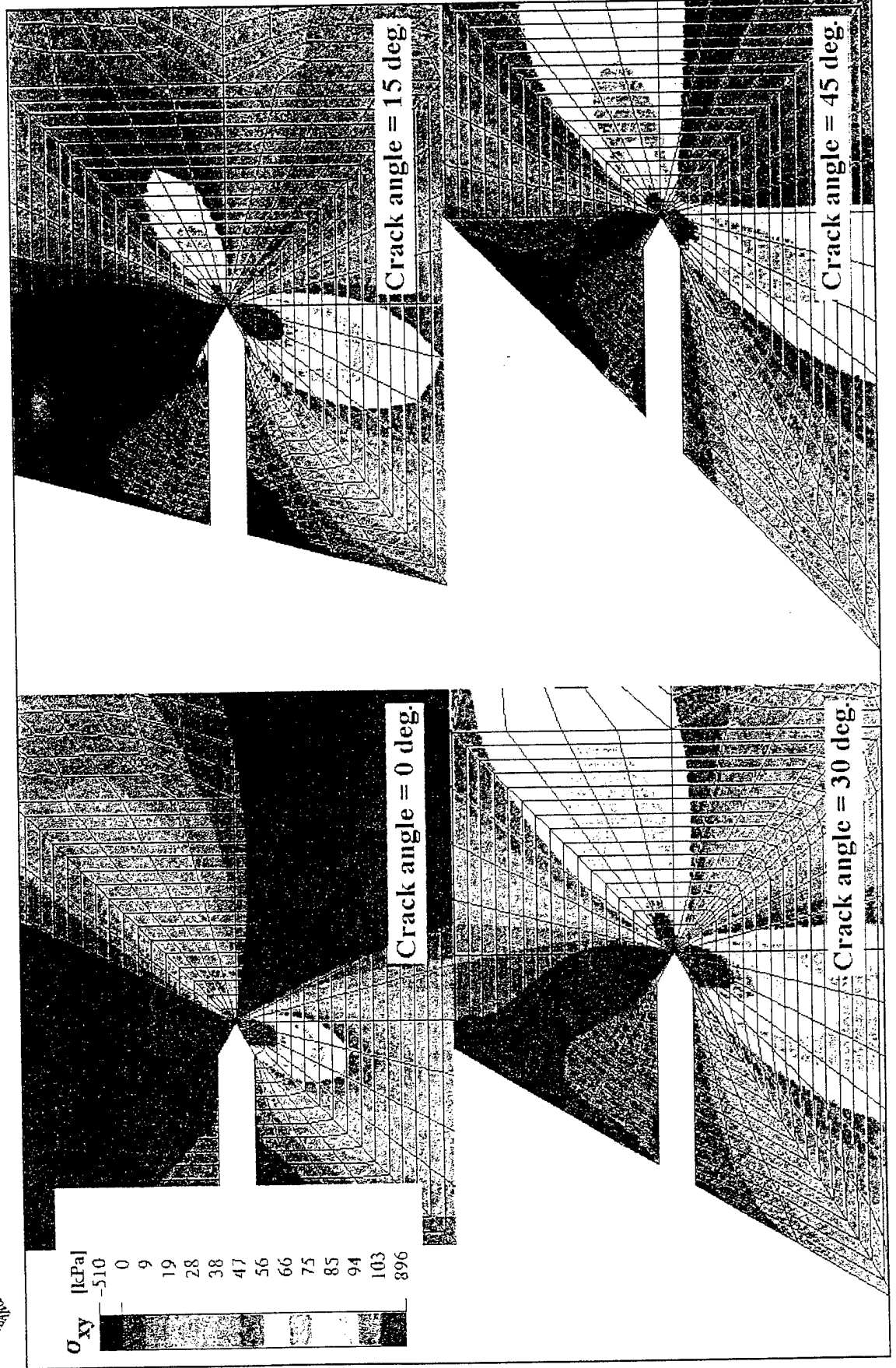
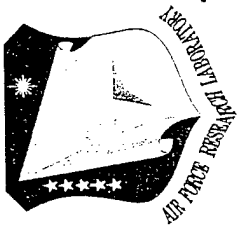




A Refined Mesh is Used to Provide Accurate Bond Line Traction

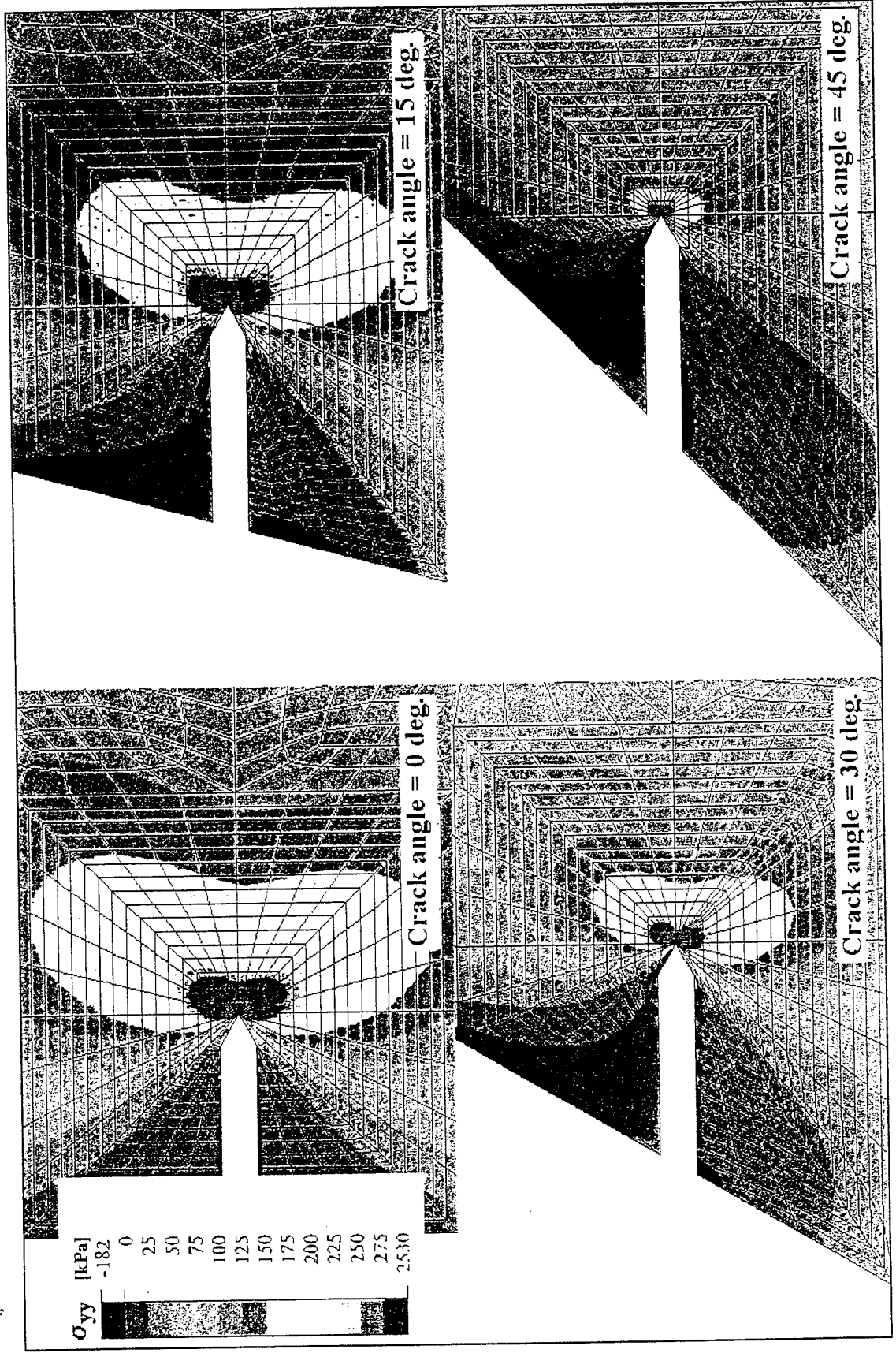


Contour Plots of In-Plane Shear Stress for Various Mode Mixities

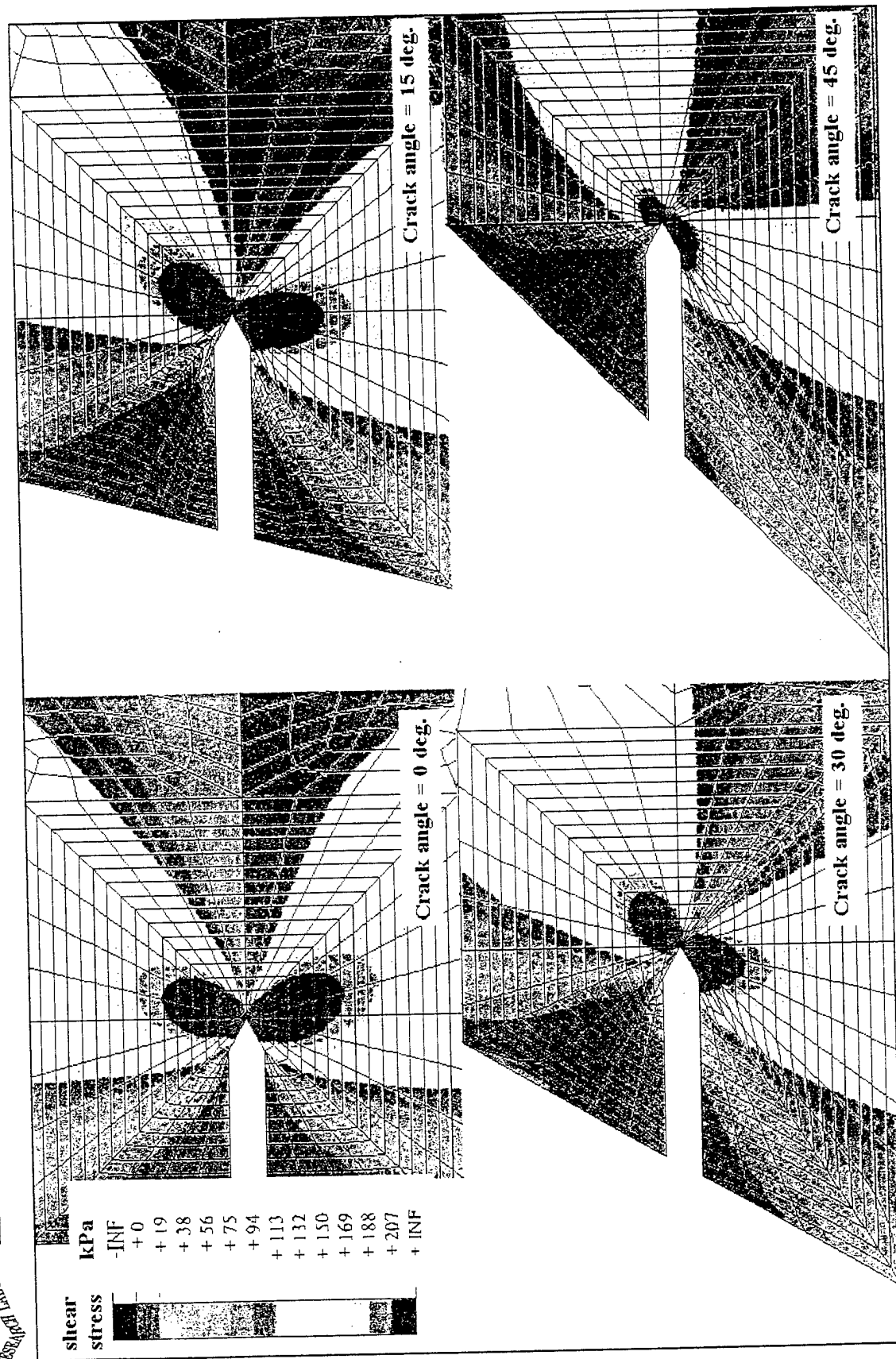
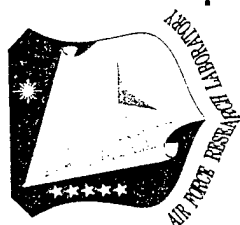




Contour Plots of σ_{yy} Stress Component for Various Mode Mixities



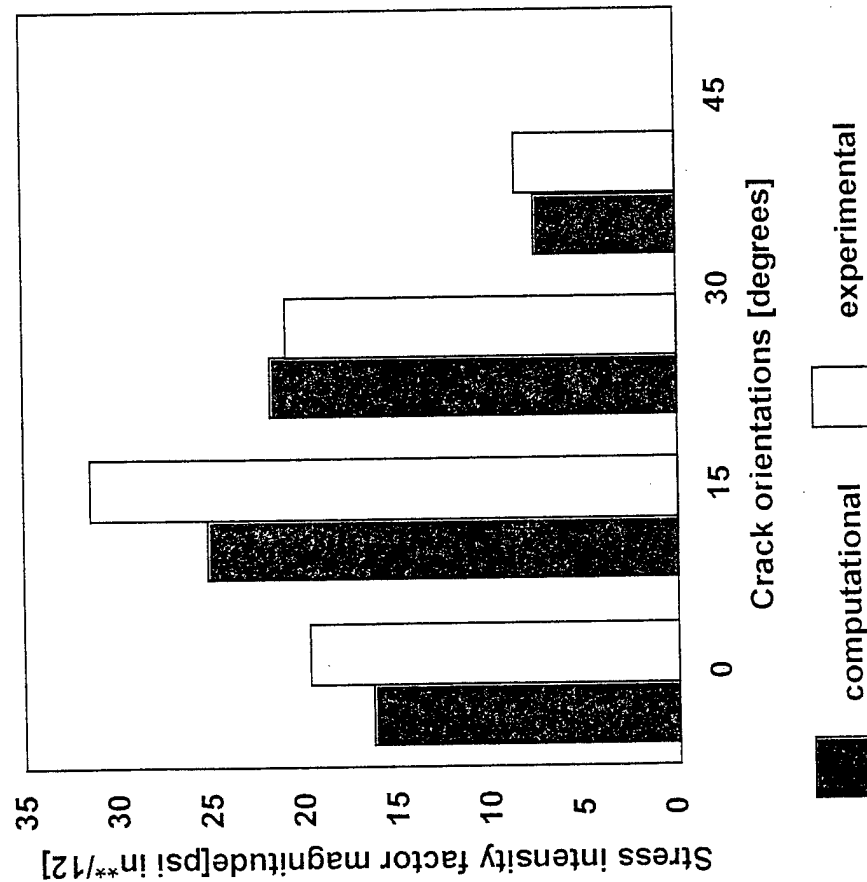
Contour Plot of Maximum In-Plane Shear Stress Component for Various Mode Mixities



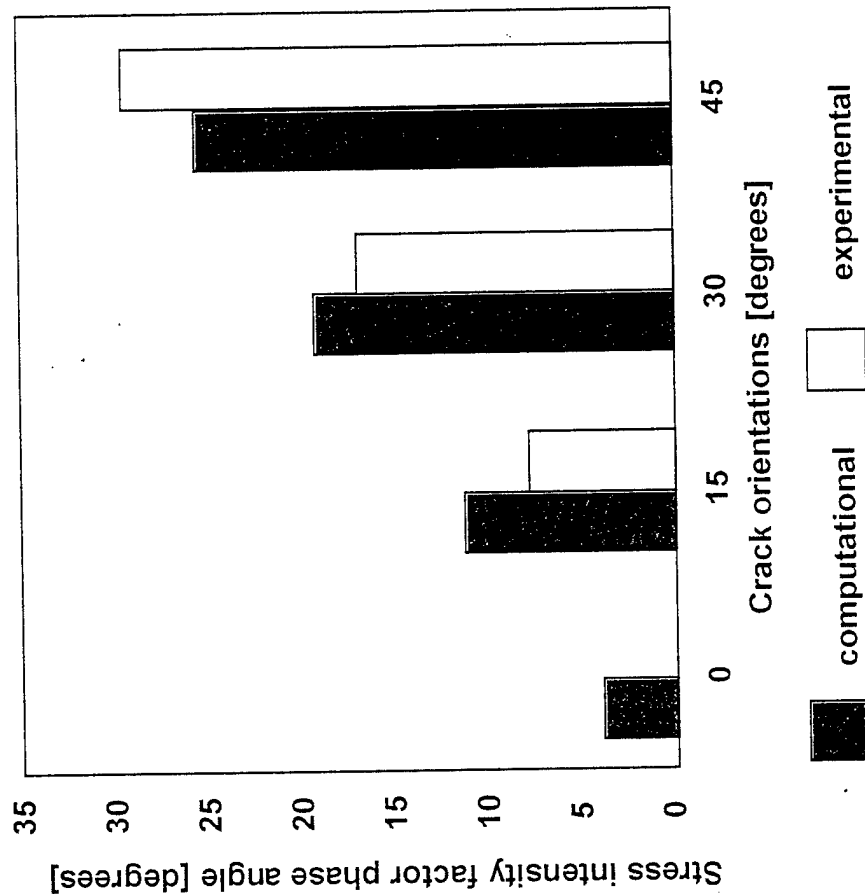


Results

Magnitude of Complex Stress Intensity Factors



Phase Angle of Complex Stress Intensity Factors





Conclusions

- Area integration and bond line traction regression is a simple and accurate way of determining the magnitude and phase angle of K for cracks along the interfaces between two incompressible materials under plane strain conditions.



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